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Hybrid technique for enhancing quality of service in wireless network

Theophilus Alumona[1], Onyinyechi Chinanuekpere Nwadiuko[1, 2, *], Lebe Agwu Nnanna[2], Chinemerem John Igbokwe[1]

[1]Dept.of Electronics and Computer Engineering, Nnamdi Azikiwe University, Awka, Nigeria
[2]Physics/Electronics Dept., Abia State Polytechnic, Aba, Nigeria

Email address:
onwadiuko@yahoo.com (O. Nwadiuko)

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Abstract: This paper x-rays a hybrid technique for enhancing Quality of Service (QoS) technique, a medium access scheme that can provide virtually collision-free environment for an infrastructure high-speed wireless network. While the simple and scalable Differentiated Services (DiffServ) QoS control model is suitable for the core part of the network, a more explicit, admission and reservation based QoS mechanisms are required in the wireless access segment of the network where the resources available and the levels of traffic aggregation render the DiffServ principles less effective, Integrated services (IntServ) provides fine-grained service guarantees to individual flows. The proposed mechanism shall support both IntServ and DiffServ QoS approaches, thereby enhancing the different QoS requirements under different scenarios.

Keywords: QoS, Hybrid Technique, Diffserv, IntServ, Wireless Network

1. Introduction

Wireless networks have various applications such as voice, data, and multimedia over packet-switched networks. Due to the fact that the characteristics of the wireless channel make high data rate very difficult to achieve, and high collision rate and frequent retransmissions cause unpredictable delays and jitters, which degrade the quality of real-time voice and video transmission [1], the QoS poses a problem from both the network and the end system. Providing quality of service (QoS) guarantees is an important objective in the design of the wireless networks [2]. Quality of service (QoS) is defined as the collective effect of service performance which determines the degree of the satisfaction of a user of service [3]. The author in [4] referred QoS as the capability of a network to provide better service to data traffic over various network technologies. Generally, QoS is the ability of a network element (e.g. an application, a host or a router) to provide some levels of assurance for consistent network data delivery [1]. It is characterised by the combined aspects of performance factors applicable to all services, such as: service support performance, service per ability performance, service accessibility performance, service retainability performance, service integrity performance and service security performance. There is a growing need to provide Quality of Service (QoS) for wireless network applications. People are now requiring to receive high-speed video, audio, voice and Web services even when they are moving in offices or travelling around campuses. Such services, especially real-time ones, require at least the same level of Quality of Service as that provided by the wired infrastructure for which most of the IP-based multimedia applications were originally designed. This leads to a problem of Quality of Service (QoS) consistency across the wireless and wired segments of the network [5-7]. The success in the deployment of such networks will critically depend upon how efficiently the wireless networks can support traffic flows with QoS guarantees [8]. To achieve this goal of QoS provisioning mechanisms, wireless networks are aimed at supporting diverse QoS requirements and traffic characteristics [9]. The performance of the network is defined by metrics and parameters such as bandwidth, packet loss, delay, and delay variation (jitter) [1, 10-12], the components necessary in network architecture for providing QoS guarantees in wireless networks include traffic specification, QoS routing, call admission control, wireless channel characterization, resource reservation, and packet scheduling. The major approaches that have been considered to cope with the problem of QoS are the integrated services (IntServ) [13] and differentiated services (DiffServ) [14]. Some previous works have been done to enhance QoS of wireless networks. The author in [11] suggests the approach of QoS considering the Enhanced Distributed Coordination Function (EDCF) and Hybrid Coordination Function. A multi-mode handoff scheme in the work of [10] includes differentiated flow handling to support flexible handoff operation that meets the different QoS requirements of various Internet services. By using flow-aware technology, the proposed scheme alleviates the limitation of the conventional packet routing in the mobile wireless network. In a work [15], a policy that aims to achieve both small packet delay and high user throughput was proposed. This work is aimed at tackling the problem of QoS from an approach that will guarantee traffic and admission control, creating resource reservation and packet scheduling; thereby creating architecture that will guarantee QoS in wireless networks.

2. Concept of QoS

2.1. Quality of Service Concept

Different wireless applications have different requirements regarding the handling of their traffic in the network. Applications generate traffic at varying rates and generally require that the network be able to carry traffic at the rate at which they generate it. In addition, applications are more or less tolerant of traffic delays in the network and of variation in traffic delay. Certain applications can tolerate some degree of traffic loss while others cannot.

Bandwidth guarantees can be requested for different time intervals depending on applications. For example, if an application is adaptive and has sufficiently large buffer space at its source and destination, the bandwidth provided by the network can vary over time, as long as the average bandwidth provided is higher than the minimum bandwidth required by the application [16]. A study [17] suggests that the network should deploy a mechanism to support bandwidth renegotiation, which allows bandwidth reservation to be provided on a finer time scale than per-session bandwidth guarantees allowed [16].

Delay occurs when a packet waits in the buffer for the service (queuing delay) and when a packet is processed for transmission in the router (service delay). We use the term queuing delay to refer to both queuing and service delay. Thus, queuing delay is equivalent to the duration from the time a packet enters the router buffer until the time it leaves the router. Delay can be analyzed in two ways; the delay pattern can be examined by its distribution and by its autocorrelation function. The autocorrelation function of delay can be used to indicate how packet delays are correlated for a sequence of packets [4]. The end-to-end delay includes the propagation delay, which is determined by the physical distance between the source and the destination; the transmission delay, which is determined by the capacity of the bottleneck link on the path; and queuing delay, which is determined by the network load, the burstiness of the traffic source, and the service disciplines employed in the network [16].

Loss can be defined as the overall loss rate, which is equal to the total amount of lost traffic divided by the total amount of input traffic over a certain period of time. Although the packet loss rate is an important parameter, it cannot adequately capture the detailed loss pattern. For the same loss rate, loss patterns may be very different. To overcome the insufficiency of the loss rate, loss pattern can be captured [4, 18, 19].

2.2. QoS Enhancement Schemes

Enhanced QoS coordination can reduce overhead, prioritize frames, and prevent collisions to meet delay and jitter requirements in mobile environment. Typically, there are two main architectural approaches to enhance the QoS over wireless networks known as the integrated services (IntServ) [13] and differentiated services (DiffServ) [1,14].

IntServ provides fine-grained service guarantees to individual flows. It requires a module in every hop IP router along the path that reserves resources for each session [1]. The IntServ architecture classifies network traffic into three classes: guaranteed service, controlled load service and best effort delivery service [20]. For traffic with guarantees, IntServ provides reservation of bandwidth and buffers by using signaling between network nodes [21]. From the point of view of performance and scalability, IntServ appeared to be a too cumbersome architecture for high-speed IP networks. Basically, the performance is limited by a router’s ability to process and maintain the set of per-connection states.

DiffServ provides a framework offering coarse-grained controls to aggregates of flows. The framework allows service providers to support differentiated services in heterogeneous network. DiffServ attempts to address the scaling issues associated with IntServ by requiring state awareness only at the edge of DiffServ domains. The DiffServ architecture uses the type of service (TOS) field in the Internet protocol header to classify flows and providing aggregate QoS to these classes. This defines the scalability of DiffServ mechanism, the most attractive attribute [22]. In DiffServ, the traffic is assigned to specific behaviour aggregates. It avoids per-flow states in the routers, and instead ingress nodes perform traffic metering and admission control on the flows [21]. The services offered to access points are statically described by service level agreements. The core of the network is considered as a DiffServ region, and all flows are mapped into one of the few DiffServ classes at the boundary.

Traffic specification specifies the source traffic characteristics and desired QoS. The network employs QoS routing to find paths between source and destinations that have sufficient resources to support the requested QoS. Based on the requested QoS, the wired link status, or the statistics of wireless channels, at each network node, call admission control scheme aims at maintaining the delivered QoS to different calls (or users) at the target level by limiting the number of ongoing calls in the system (decides whether a connection request should be accepted or rejected). Wireless channel characterization is needed to specify the statistical

QoS measure of a wireless channel at the base station, e.g., a data rate, delay bound, and delay-bound violation probability triplet; this information is used by call admission control. If a connection request is accepted, resource reservation at each network node allots resources such as wireless channels, bandwidth, and buffers that are required to satisfy the QoS guarantees. During the connection life time, packet scheduling at each network node schedules packets to be transmitted according to the QoS requirements of the connections.

2.3. Heterogeneous Network Characteristics

Cellular networks provide ubiquitous connectivity but low data rates, whereas Wireless Local Area Networks (WLANs) can offer much higher data rates but only cover smaller geographic areas. Their complementary characteristics make the integration of the two networks a promising trend for next-generation wireless networks. With combined strengths, the integrated networks will provide both wide area coverage and high rate data services in hotspots [23]. Nevertheless, WLANs still cannot be expected to support the same level of QoS as cellular networks. As a result, QoS provisioning in cellular networks and the relatively weak QoS support capability of WLANs need to be taken into account for resource allocation in cellular and WLAN interworking.

Resource allocation solutions differ in cellular networks and WLANs due to the heterogeneity in the physical, medium access, and link control layers. In cellular networks, based on a centralized architecture, the base station has the ability to provide QoS guarantee to mobile stations via properly scheduling their access to the wireless channel, taking advantage of the information available in the base station and collected from mobile stations. Furthermore, the schedulers located in different base stations can also coordinate with each other to improve overall system performance. For the multiple access uplink (from mobile station to base station), a two-phase request-grant access procedure is used in cellular networks. First mobile stations send transmission requests to the base station through a contention channel. The base station acknowledges those successful requests and reserves resources for data transmission to follow. Then the Mobile Stations are notified the resource assignments. This type of centralized control and reservation-based resource allocation, together with proper admission control to limit the traffic load, enable more refined QoS provisioning in cellular networks.

The most widespread wireless technology of choice in WLAN and ad-hoc networks is standard IEEE 802.11, with enhancement to IEEE 802.11e [24].

2.4. IEEE 802.11 Network and IEEE 802.11e QoS Enhancement

802.11e is a specification, approved by the IEEE in late 2005, to define QoS mechanisms for wireless gear that gives support to bandwidth-sensitive applications such as voice and video. It is the most deployed wireless technologies all over the world and may be applied in the next-generation wireless communication network. It is characterized by its simplicity, flexibility and cost effectiveness.

The IEEE 802.11 standard specifies two medium access control (MAC) functions, the mandatory Distributed Coordination Function (DCF) and the optional Point Coordination Function (PCF) [23, 25, 26]. The Distributed Coordination Function (DCF) allows sharing of the wireless medium between compatible physical layers through the use of a carrier sense multiple access technique with collision avoidance (CSMA/CA) protocol and this mechanism is mandatory for all stations, including 802.11e QoS-supporting stations [11]. In the DCF access mode, several stations may randomly select particular backoff timer values that cause them to transmit at the same time. In such cases, signal collisions occur and all stations involved must retransmit the given data frame and repeat the random backoff procedure with a new timer value. In addition, stations may have to unnecessarily wait longer than required before getting a chance to transmit if they happen to select a large backoff timer value. The collision problem becomes more and more severe as the number of contending stations in the network grows and the size of transmitted data frame increases [25].

The Point Coordination Function (PCF) is optional and was designed to support time-bounded services. PCF has a Point Coordinator (PC) to control the contention free access to the wireless medium [11] by controlling the transmission of prioritized traffic. PCF uses a centralized polling scheme, which requires the Access Point (AP) as a point coordinator (PC) and is co-located with the AP [1]. PCF supports time-sensitive traffic flows [11]; between two consecutive beacon frames periodically sent by the AP (superframe), the IEEE 802.11 defines the Contention period (CP) and the Contention free period (CFP).

Though PCF was designed to support time-bounded traffic [27], it shows many inadequacies such as unpredictable beacon delays due to incompatible cooperation between CP and CFP [28, 29]. To setup and control PCF operations, there is no management interface, so it is not possible to setup a PCF policy according to the requirements of higher layer protocols such as Differentiated Service or Integrated Service [27, 30].

The Enhanced Distribution Coordination Function (EDCF) is an enhancement of DCF, and introduces three parameters, namely, Arbitration Inter-Frame Space (AIFS), CWMin (minimum initial value of the Contention Window (CW)) and CWMax (minimum value of the CW) which can be determined and announced by the AP via beacon frames. Depending on the network conditions, the AP can adapt these parameters. EDCF introduces Traffic Category (TC) to realize QoS. When the channel is idle for a new kind of inter frame space called AIFS, each TC starts a back-off. It is designed for the contention-based prioritized QoS support [1]. The EDCF support DiffServ in two methods-firstly, the AIFS are categorized for high priority queues and low priority queues and transmitted according to the level of priority with the AIFS of lower number assigned granted access first and the others follow within given time slot, and secondly involves the allocation of different Contention Window sizes for different access category (AC) to ensures that in most cases, high-priority access category is able to transmit packets ahead of low-priority one [1, 31].

AIFS is to EDCF as DIFS in DCF and can be chosen individually for each TC to provide a deterministic priority mechanism between the TCs. As such, the CWMin can be selected per TC basis and the subsequent CW is doubled when collisions occur [32]. The CWMax sets the maximum possible value for the CW and is intended to be the same for all TCs as in DCF. Generally, the smaller the AIFS and CWMin the shorter the channel access delay [32], and hence the more the bandwidth share for a given traffic condition. EDCF also provides differentiated and distributed channel access for frames with 8 different priorities (from 0 to 7).

The Hybrid Coordination Function (HCF) is a queue-based service differentiation scheme using both PCF and DCF enhancements. It combines the advantages of distributed contention access (EDCF) and centralized polling access (PCF) methods. HCF uses QoS-enhanced access point (QAP) as a traffic director for different queues. It supports parameterized traffic similar to the IntServ protocols. The HCF is an extension of the polling data in PCF. As in PCF, under HCF, the superframe is divided into the CFP and CP. The polling in the HCF is controlled by the Hybrid coordination (HC) and The HC is co-located with the QoS supporting Access Point (QAP). HCF has an EDCF which is a contention based access mechanism that operate concurrently with HCF based on a polling protocol controlled by the HC. One of the main features of the HCF is the introduction four access category (AC) queues and eight traffic stream (TS) queues at MAC layer. When a frame arrives at MAC layer, it is tagged with a traffic priority identifier (TID) according to its QoS requirement, which can take the values from 0 to 15. The frames with TID values from 0 to 7 are mapped into four AC queues using EDCF access rule. On the other hand, frames with TID values from 8 to 15 are mapped into eight TS queues using HCF controlled channel access rule. The reason of separating TS queues from AC queues is to support strict parameterized QoS at TS queues while prioritized QoS is supported at AC queues [1].

The HCF also grants Transmission opportunity (TXOP), which is defined by the start time and maximum duration. TXOP is the time interval permitted for a particular STA to transmit packets. The hybrid controller, HC, polls stations during a contention-free period. The polling grants a station a specific start time and a maximum transmit duration.

3. Hybrid Technique for Enhancing QoS

The proposed technique support different QoS enhancement schemes. It applies the DiffServ architecture and uses the IntServ management model. IntServ is not deployed here since its requirement of setting states in all routers along a path is not scalable. But the IntServ principles of explicit admission control and reservation are applied locally to the QoS control over the wireless access segment. The resource management at the access network level is based on functional blocks typical of IntServ model, that is, admission controller and packet (frame) classifier, with multiple queues and service disciplines used to enforce QoS guarantees given to the flows (sessions) upon admission.

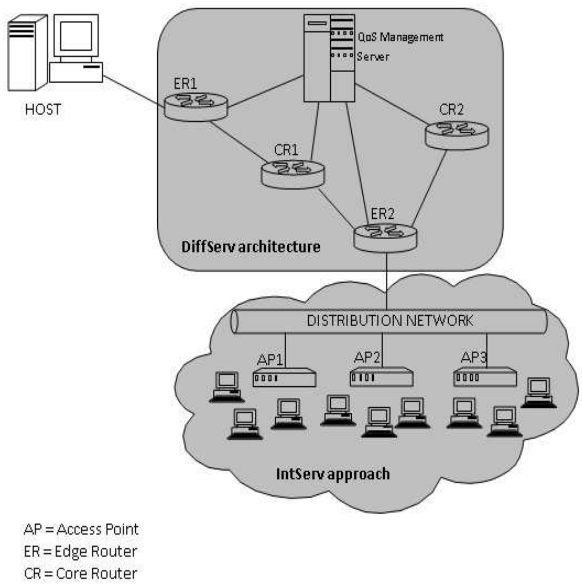

Figure 1. *Hybrid Technique for QoS Enhancement.*

DiffServ attempts to address the scaling issues associated with IntServ by requiring state awareness only at the edge of DiffServ domains. DiffServ approach of QoS provisioning guarantees scalability and efficient control in networks with high resource and traffic specification, but is lacking in the provision resource reservation for aggregate traffic.

At the edge, packets are classified into flows, and the flows are conditioned to a traffic conditioning specification (TCS). In this way, more simple and effective QoS support can be built from the components during early deployments, and Internet-wide QoS can evolve into a more sophisticated structure. The IntServ QoS provision can be made using DiffServ network segments. This solution maintains the IntServ signaling, delay-based admission and the IntServ service definitions.

Though QoS can be provided when PCF and DCF mode of provisioning are adapted, where DCF guarantees equal transmission opportunities for each wireless node in heavily loaded servers and the PCF supports time-bound traffic. The performance of the DCF scheme significantly degrades when there are a large number of active client stations in the network due to the more severe collision problem, while the performance of the PCF scheme significantly degrades when the number of inactive stations increases.

To optimize the performance of the polling algorithm in the PC, stations need to communicate QoS requirements to the AP. But, there is no mechanism for this in PCF. Since performance optimization is not possible, neither DCF nor PCF provide sufficient facility to support traffic with QoS requirements proposed.

But, EDCF introduces the concept of traffic categories. Each station has eight traffic categories, or priority levels. Using EDCF, stations try to send data after detecting the medium is idle and after waiting a period of time defined by the corresponding traffic category. HCF, which is similar to IntServ protocol, allows the AP to poll clients during CFP and allocate them a TXOP during CP at specified start time and maximum duration.

The HCF offers enhanced QoS control, more efficient use of the medium when heavily loaded and fairly in channel utilization. Due to reduced overhead, HCF provide better QoS support for high priority streams while allocating enough bandwidth to lower priority streams. HCF is AP localized, creating a simple QoS mechanism.

4. Conclusion

In conclusion, in order to support internet protocol based QoS approaches in wireless links, different kinds of QoS enhancement schemes for both infrastructure and ad-hoc modes have been x-rayed for WLAN, ranging from the enhanced DCF model, EDCF to the application of HCF which combines DCF, PCF and the EDCF mechanisms.. The hybrid technique applies the simple and scalable DiffServ QoS control technique but applies the IntServ explicit admission control and resource reservation management in the wireless network.

The suggested technique is differentiated and distributed, and also grants admission control mechanism that checks for network overload. Stations with high priority traffic can have advanced traffic schedules guaranteeing QoS requirements for traffic issues.

References

[1] Q. Ni, L. Romdhani and T. Turletti, “A Survey of QoS Enhancements for IEEE 802.11 Wireless LAN,” J. Wireless Comm. and Mobile Computing, Wiley, vol. 4(5),, pp. 547-566, 2004.

[2] L. Zheng, A. Dadej and S. Gordon, “Hybrid Quality of Service Architecture for Wireless/Mobile Environment, in IFIP — The International Federation for Information Processing, Converged Networking, vol. 119, C. McDonald , Ed. 2003, pp. 341-352

[3] S. Maïza, “Mastering quality of service in GPRS/UMTS An overview,” in Annales Des Télécommunications, 2005, pp. 472-499

[4] B. Chen, “Simulation and Analysis of Quality of Service Parameters in IP Networks with Video Traffic,” B.Sc. Thesis, Engineering Science, Simon Fraser University, 2002.

[5] S. Maniatis, C. Grecas and L. Venieris, "End-to-end quality of service issues over next generation mobile Internet", Communications and Vehicular Technology, 2000. Symposium on, P150 -154

[6] S. Dixit, Y. Guo Z. Antoniou, “Resource management and quality of service in third generation wireless networks,” IEEE Communications Magazine, vol. 39 -2, pp. 125 -133, February 2001.

[7] R. Koodli and M. Puuskari, “Supporting packet-data QoS in next generation cellular networks,” IEEE Communications Magazine, vol. 39(2), pp. 180-188, Feb. 2001.

[8] B. Jabbari, “Teletraffic aspects of evolving and next-generation wireless communication networks,” IEEE Personal Communications Magazine, pp. 4–9, 1996.

[9] H. Holma and A. Toskala, WCDMA for UMTS: Radio Access for Third Generation Mobile Communications, Wiley, 2000.

[10] T. Yim, T. Nguyen, K. Hong, Y. Kyung and J. Park, “Mobile flow-aware networks for mobility and QoS support in the IP-based wireless networks,” Wireless Network, vol. 20, pp. 1639–1652, 2014.

[11] M. Based, “A Survey about IEEE 802.11e for better QoS in WLANs,” Novel Algorithms and Techniques in Telecommunications and Networking, Sobh et al. Eds., 2010, pp. 195-200.

[12] I-H. Hou, V. Borkar and P. Kumar, “A Theory of QoS for Wireless,” IEEE Infocom 2009, pp. 486-494.

[13] R. Braden, D. Clark and S. Shenker, “Integrated services in the Internet architecture: an overview,” IETF Standard RFC 1633, 1994.

[14] S. Blake, F. Baker and D. Black, “An architecture for differentiated services,” IETF Standard RFC 2475, 1998.

[15] K. Johnsson and D. Cox, “An adaptive cross-layer scheduler for improved QoS support of multiclass data services on wireless systems,” IEEE J. on Selected Areas in Communications, vol. 23(2), 2005.

[16] G. Aggélou, “An Integrated Platform for Quality-of-Service Support,” in Mobile Multimedia Clustered Ad Hoc Networks, M. Ilyas, Ed. 2003, pp. 414-436.

[17] M. Grossglauser, S. Keshav, and D. Tse, RCBR: A Simple and Efficient Service for Multiple Time-Scale Traffic, IEEE/ACM Transactions on Networking, To appear, Dec. 1998

[18] F. Xue, V, Markovski and L. Trajkovic, "Packet loss in video transfers over IP networks," in Proc. IEEE Int. Symp. Circuits and Systems, Sydney, Australia, vol. II, 2001, pp. 345-348

[19] V. Markovski, "Simulation and Analysis of Loss in IP Networks. M.A.Sc. Thesis, Engineering Science, Simon Fraser University, 2000.

[20] S. Pack and Y. Choi, "An End-To-End Qos Provisioning Architecture in Mobile Network, in Proc. International Symposium on Communications and Information Technologies, Chiangmai, Tailand, 2001, pp. 5-8.

[21] E. Ossipov and G. Karlsson, "A Simplified Guaranteed Service for the Internet," in Protocols for High Speed Networks, Lecture Notes in Computer Science, vol. 2334, Carle and Zitterbart (eds.), 2002, pp. 147-163.

[22] I. Mahadevan and K. Sivalingam, "Architecture and Experimental Framework for Supporting QoS in Wireless Networks Using Differentiated Services," Mobile Networks and Applications, vol. 6, pp. 385–395, 2001.

[23] H. El-Sayed, A. Mellouk, L. George and S. Zeadally, "Quality of service models for heterogeneous networks: overview and challenges", Ann. Telecommun., vol. 63, pp. 639–668, 2008.

[24] A. Hamidan and U. Korner, "An Enhancement to the IEEE 802.11e EDCA providing QoS Guarantees," Telecommun Syst., vol. 31, pp. 195-212, 2006.

[25] S. Siwamogsatham, "A Hybrid Coordination Function Scheme for WLANs," J. Hybrid Inform Tech., vol. 1(3), pp.33-46, 2008.

[26] K. Pahlavan and P. Krishnamurty, Principles of Wireless Networks. PTR: Prentice Hall, 2002.

[27] S. Mangold, S. Choi, P. May, O. Klein, G. Hiertz and L. Stibor, "IEEE 802.11e WLAN for Quality of Service," European Wireless, 2002, Italy.

[28] Q. Ni and T. Turletti, "QoS support for IEEE 802.11 Wireless LAN." Technical report, PLANETE Group, INRIA Sophia Antipolis, 2004.

[29] P. Garg, R. Doshi, R. Greene, M. Baker, M. Malek and X. Cheng, "Using IEEE 802.11e MAC for QoS over Wireles"s. Computer Science Department, Stanford University, USA, 2003, pp. 537-542.

[30] W. Stallings Data & Computer Communications. 6th ed., Prentice Hall International, Inc, 2000.

[31] L. Romdhani Q. Ni and T. Turletti, "Adaptive EDCF: Enhanced Service Differentiation for IEEE 802.11 Wireless Ad Hoc Networks" IEEE WCNC, 2003 [Wireless Communications and Networking Conference, New Orleans, Louisiana].

[32] S. Park and K. Hong, "Collaborative QoS Architecture between DiffServ and 802.11e Wireless LAN" Vehicular Technology Confer., vol. 2, pp. 945-949, April, 2003.